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POINTS CONCERNING REINFORCED CONCRETE ABUTMENTS

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The term abutment usually implies not only a support for a bridge, but also what is virtually a retaining wall. In the case of an arch bridge, the horizontal thrust transmitted by the arch is always sufficient to resist the overturning pressure of the earth behind the abutment; but in the case of abutments supporting truss bridges, to which case the scope of this article is confined, the abutment must be designed as a retaining wall, since no horizontal thrust is communicated through the bridge.

The past few years have seen a tremendous growth in the use of concrete for almost all forms of construction. This growth is, to a large extent, due to the reduced cost of Portland cement, coincident with a vast improvement in quality. The use of steel in overcoming the inability of concrete to resist tensile stresses was a remarkable discovery. This combination of concrete and steel is made possible by the fortunate coincidence of their coefficients of expansion and contraction. It virtually gave the world a new material, steel concrete, the possibilities of which, with further study and knowledge, are almost unbounded.

The adaptability of reinforced concrete for the construction of bridge abutments, is due to the following reasons:

Economy; durability; fireproof qualities; low maintenance cost; reliability of stresses compared to stresses in masonry; and facility of erection.

Types

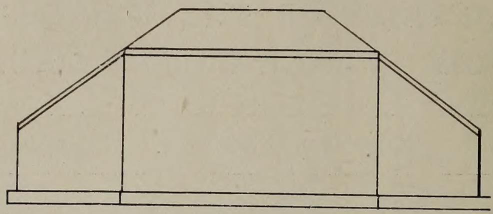
Reinforced concrete abutments may be divided into three different types, namely;

(1) Abutments with flaring wing walls, as in Fig. 1 which run back at approximately 30 degrees with the face wall, and decrease in height to correspond with natural slope of embankment.

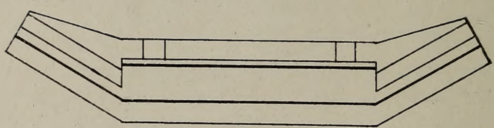
(2) "U" shaped abutments, as in Fig. 2, consisting of a head

wall, and two walls which run back perpendicular to the head wall. This type is rarely used except in very special cases.

(3) "T" shaped abutments, as in Fig. 3, consisting of a head wall, which has a core wall extending perpendicularly back from the centre. The core acts as a tie, and prevents overturning. Great



ELEVATION



PLAN

Fig. 1. Type of Wing Abutment

care is required in the construction of this type, as tensile stresses at union of core and head walls are usually high.

Abutments with flaring wing walls are most commonly used, especially in highway construction, where the approach to bridge is invariably earth enbankment, and where the usual height of abutment does not exceed 30 feet. In this type, if the angle between the centre line of the road and wing wall be not too great, the dead weight of the wings, if they are properly connected to face wall by continuous reinforcement, will resist to a considerable extent the overturning effect of the lateral earth pressure against face wall.

Types (2) and (3) are used occasionally in railway construction, where right-of-way is restricted to small area, or where it would be difficult to obtain foundations for type No. 1, on account of possible interference with sewers, watermains, or other forms of subterranean construction.

Earth Pressures and Retaining Walls

The design of abutments resolves into the solution of beams and cantilevers. As the type of abutments under consideration must be designed as retaining walls, we shall now consider theories as to the stability of earth, and the formulae for the determination of the resultant earth pressure against a vertical wall.

The stability of a retaining wall is a comparatively simple matter when three quantities have been determined, namely:

(1) The intensity of the earth pressure;

(2) The point of application of the resultant earth pressure, and
(3) The line of action of this pressure.

Unfortunately earth material is very variable in its action depending upon conditions, such as the degree of saturation with water which affects, to a considerable extent, the angle of repose of the material, and consequently, as this angle is included in all theoretical formulae pertaining to earth pressure, we shall encounter considerable difficulty in determining its numerical value. In this connection Mr. T. Kennard Thomson, one of the most eminent men in the structural engineering profession, states: "The objection to the angle of repose is, that it is not possible to ascertain it for any material deposited by nature, for it is known that nearly all earth and etc., has been deposited under great pressure, and is likely to be cemented together by clay, loam, roots, trees, boulders and etc., and differs in character every few feet." We can, however, measure fairly accurately the angle of repose for materials deposited by man, and the following table gives the generally accepted values of that angle for stated materials, as well as their weights per cubic foot.

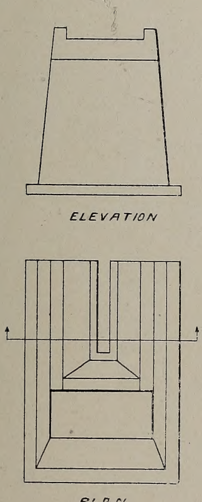


Fig. 2. "U" Abutment

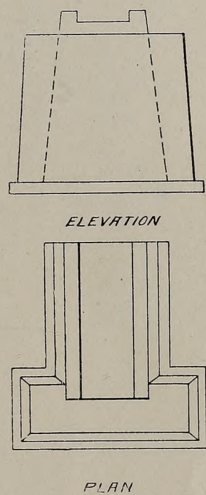


Fig. 3. Type of "T" Abutment

Soil	*lbs. cu. ft.*	*Angle of repose*
Vegetable earth	90	30 degrees
Sandy loam	100	34 degrees
Loamy clay	110	36 degrees
Firm gravel	120	40 degrees
Loose gravel	110	36 degrees
Stiff clay	128	45 degrees
Wet clay	120	16 degrees

The theories regarding the lateral pressure of earth are varied,

and in no ways consistent. For example, there is a difference of opinion as to whether or not the lateral pressure increases with the depth. Mr. J. C. Meem in a paper entitled "Pressure, Resistance and Stability of Earth," describes several very interesing experiments on the arching tendency of materials. He believes he has demonstrated that the lateral pressure is greatest near the surface, and expresses his conclusions as follows: "All the experiments and observations noted, point conclusively to the fact that pressure is transmitted laterally through ground most probably along, or nearly parallel to, the angle of repose, or in cases of rock or stiff material, along a line which, until more conclusive experiments are made, may be taken as a mean between the horizontal and vertical or approximately 45 degrees. There is no reason to believe that this is not the

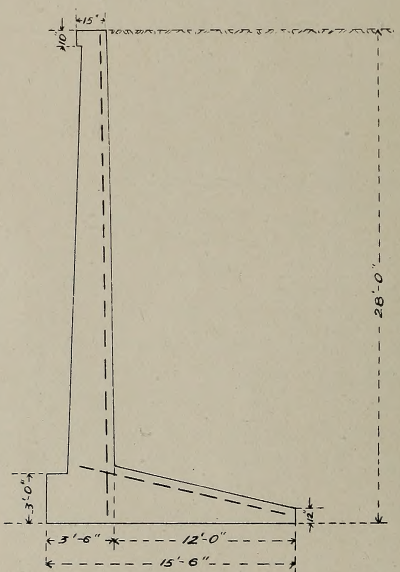


Fig. 4

case throughout the entire mass of the earth, that each cubic foot, or yard, or mile, is supported, or in turn supports its neighboring equivalent along such lines. The theory is not a new one, and its field is too large to encompass within the limits of a single paper, but, for practical purposes and within the limited areas to which we must necessarily be confined, the writer believes it can be established beyond controversy as true. Certain it is that no one has yet found, in ground free from water pressure or abnormal conditions, any evidences of greater pressure at the bottom of a deep shaft or tunnel than that near the surface."

In the discussion of the paper from which the above quotation (Trans. Am. Soc. C. E., Vol. 70) was taken, Mr. Goodrich states that Mr. Meem's theory of pressures against retaining walls, being a

maximum at top and decreasing to zero at the bottom, is an absolute contradiction to the results of experiments performed by him during the erection of a reinforced concrete retaining wall on Staten Island, New York City, in which the usual law of increase of lateral pressure with depth is believed to be demonstrated beyond question. The opinion of Mr. Goodrich is the one more generally accepted, and on the basis of which all retaining walls known to the writer have been designed.

It is comparatively easy to formulate a theory regarding the pressure of earthwork, which shall be based on certain theoretical assumptions. One of these assumptions is, that the so-called plane of rupture is a plane surface. Another that is sometimes made is that the earthy material acts virtually as a liquid, with a much greater

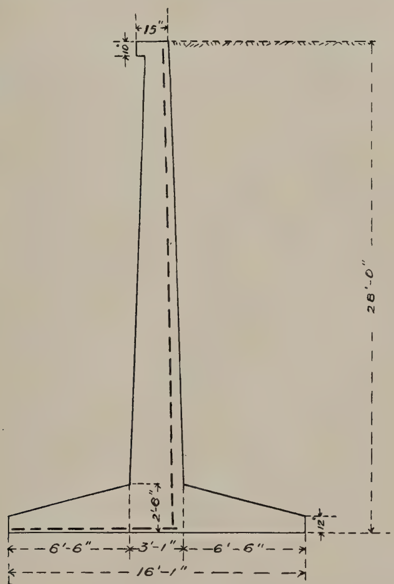


Fig. 5

density than water, while others assume that the action of earth pressure is more closely allied to that of a coherent solid than to an aqueous or frictionless mass.

Theoretically the design of retaining walls is very much complicated by the question of the earth pressure that may be produced by a surcharged wall. The writer is inclined to agree with Mr. H. E. Bilger, who, in a paper read before the Illinois Society of Engineers and Surveyors, stated: "To design economically a retaining wall and ensure stability is a problem that is not susceptible of accurate mathematical solution. A great many formulae have been advanced that deal with earth pressure under different conditions, and, as a rule, they all give results that are safe, but the formulae themselves are necessarily based upon assumptions that are more or less unknown

and consequently for ordinary cases, there is little or nothing to be gained in applying a supposedly rational formula to determine the stability of a retaining wall against overturning."

Reinforced concrete retaining walls are built upon different principles to those of masonry or plain concrete. They rely chiefly upon their strength and not upon their weight, and can be divided into four general types, as follows:

(1) "L" shaped. Footing held down by weight of earth. Thrust resisted by cantilever.

(2) Wall at centre of footing.

(3) Wall at outer edge of footing.

(4) Case (2) with counterforts.

These are shown in Figs. 4 to 7, respectively.

Type (4) is the one more commonly used, but even in this type,

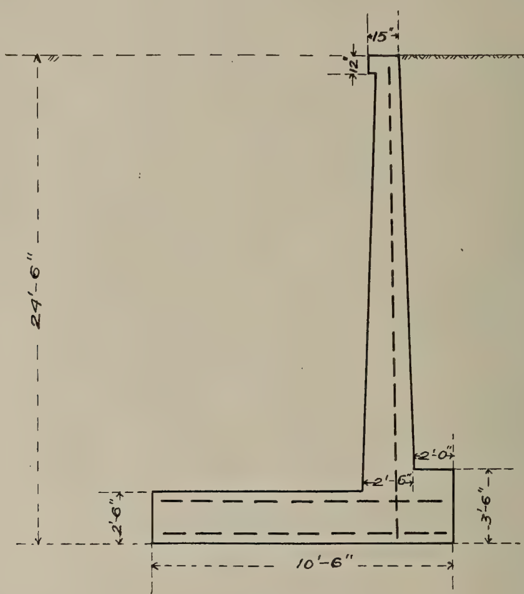


Fig. 6.

which has decided advantages over the others, it is unusual to find a wall, which has been erected for any length of time, that does not show evidences of failure or at least defects. From these conditions it is evident that the present formulae and arbitrary rules for the design of retaining walls are very inadequate.

The use of a fixed ratio of base to height is a common practice in the design of retaining walls. These ratios vary from .33 to .60, but the ratio most commonly used is .50. It is the practice of the Illinois Highway Commission to make the base of a reinforced retaining wall 33% of the total height, the footing depth being usually 18 inches, while the Board of Highway Commissioners for the Provce of Saskatchewan use the ratio .50.

The resultant force on a retaining wall is always inclined to the vertical, this being dependent on the relative intensity of the weight of the wall acting vertically through the centre of gravity of its mass, and the intensity of the pressure of the earth on the wall, together with its direction. This obliquity of the resultant force causes two tendencies: the one is to cause the wall to slide upon the foundation bed, the other is to overturn the wall bodily around some axial line. Other methods of failure are bulging, due to insufficient thickness, and failure of foundation in bearing capacity.

In spite of the unreliability of theoretical formulae, for the reasons before stated, certain formulae, which are here quoted, are sometimes

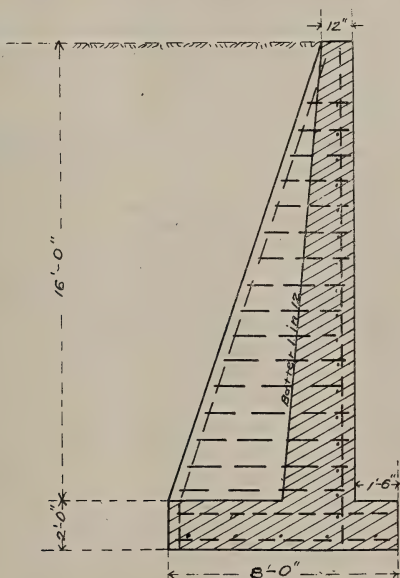


Fig. 7

used for lack of better formulae, as a guide in determining the thickness of a wall.

Let E = Total pressure against rear face of wall on unit length of wall.

w = Weight of unit volume of earth

h = Height of wall

θ = Angle of repose with horizontal.

Then when upper surface of earth is horizontal, we have the equation,

$$E = \operatorname{Tan}^2\left(45^\circ - \frac{\theta}{2}\right) \cdot \frac{wh^2}{2} \qquad \text{.........(1)}$$

If upper surface is surcharged with a bank of earth at a natural slope, or if the angle of slope of the surcharge $= \theta$, then the equation becomes,

$$E = \tfrac{1}{2} \cos \theta \, w \, h^2 \qquad \text{.........(2)}$$

From (1) we see that the pressure is greater for small values of θ.

This pressure is assumed to act at a point one-third of the distance from the base, when calculating the overturning moment.

Rankine's Formula

P = Resultant horizontal pressure on wall in pounds.
p = Pressure per square foot on wall in pounds.
w = Weight of earth per cubic foot.
h = Height of wall.
θ = Angle of surface of back-filling.
θ = Angle of repose of material.

Then at any height, "h"

$$P = \frac{wh^2}{2} \cos \theta . \cos\theta - \sqrt{\cos^2 \theta - \cos^2 \phi} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

$$\cos\theta + \sqrt{\cos^2 \theta - \cos^2 \phi}$$

At top of embankment $\theta = 0°$, then the formula becomes,

$$P = \frac{wh^2}{6} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

and $p = \frac{wh}{3}$, hen $\phi = 30°$

That is "p," the horizontal pressure per square foot at any depth on face wall is one-third the vertical pressure per square foot at same point.

J. C. Meem's Formula

If A O, Fig. 8, be face of wall, and OCJ, the natural slope of the earth, θ being the angle of repose

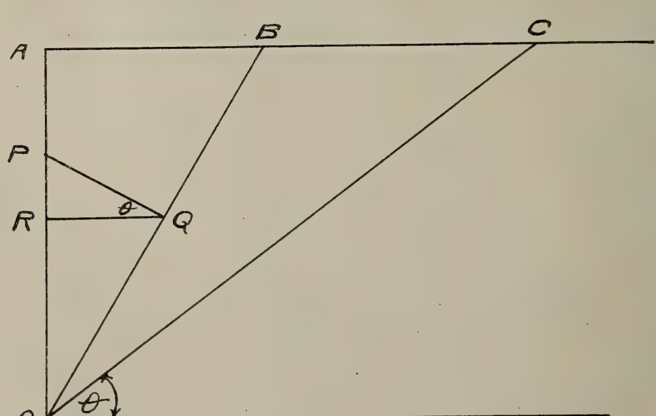


Fig. 8

Then the mass causing pressure against the line AO. is contained in the triangle AOC

As thrust is greatest in material directly at the face, and is

nothing at the plane of repose CO, it may be assumed arbitrarily that the line BO bisecting the angle

$C\ O\ A$ divides the area $A\ O\ C$ into two parts, in one of which the weight resolves itself wholly into thrust, and the other being an area of weight only, bearing on the plane of repose. Calling the line $B\ O$ the haunch line, the thrust in the area $A\ O\ B$ is measured by its weight divided by the tangent of the angle $P\ Q\ R$ (equals θ), which is the angle of repose, that is, the thrust at any point "R" equals $R\ Q$ divided by the tangent of θ.

"The writer suggests that in those materials which have steeper angles of repose than 45°, the area of pressure may be calculated as above, the pressure being computed however as for an angle of 45°."

In calculating the bending moment against a wall or bracing, there is the weight of the mass multiplied by the distance of its centre of gravity vertically above the toe, or approximately:

Area $A\ O\ B$ x Weight per unit x 2/3 height.

When h = height

w = weight per cubic foot of material

$$\beta = \frac{90-\theta}{2}$$

$$\text{Then } M = h + \frac{h}{2}\left(\text{Tan } \beta\right) w.\ 2/3\ h.$$

$$= 1/3\ h^3\ w \text{ Tan } \beta \qquad (5)$$

When the angle of repose θ is less than 45°, this result must be reduced by dividing by Tan θ, that is

$$M = 1/3\ h^3\ w \text{ Tan } \beta \div \text{Tan } \theta.$$

Carter's Formula

$P1$ = Resultant pressure

w = Weight of cubic foot of earth in lbs.

h = height of wall in feet

θ = Angle between back of wall and horizontal

ϕ = Natural slope of material

δ = Angle between surface of surcharge and horizontal.

Then

$$P_1 = \frac{1/2\ w\ h^2 \text{ sine}^2 (\theta - \phi)}{\sin^3\theta \left\{ 1 - \sqrt{\dfrac{\sin\phi \text{ sine } (\phi - \delta)}{\sin\theta \sin\ (\theta - \delta)}} \right\}} \qquad (6)$$

When $\delta = \phi$, i.e., when surcharge lies at the angle of repose

$$P_1 = 1/2w\ h^2 \frac{\sin^2\ (\theta - \phi)}{\sin^3\ \theta} \qquad (7)$$

When $\delta = \phi$ and

$\theta = 90°$, i.e., when back of wall is vertical

$$P_1 = 1/2\ w\ h^2 \cos^2\phi \qquad (8)$$

When $\delta = \theta°$ i.e., when top surface is level

$$P_1 = \frac{1/2\ w\ h^2 \sin^2 1/2\ (\theta + \phi)}{\sin\ \theta \sin^2\ 1/2\ (\theta + \phi)} \qquad (9)$$

When $\delta = 0°$

$\theta = 90°$

$$P_1 = 1/2\ w\ h^2 \tan^2 (45 - 1/2\phi) \qquad (10)$$

which is the well known expression first deduced by Coulomb in 1773 and so admirably set forth by Professor Merriman in "A Text Book on Retaining Walls and Masonry Dams."
This is equal to

$$P_1 = 1/2\ w\ h^2 \frac{(1-\sin\phi)}{(1+\sin\phi)}$$

as given by Rankine.

Let pressure per square foot at depth $y = P_2$

$$P_1 = 1/2\ h\ z \qquad \text{or,}\ z = \frac{2P_1}{h}$$

$$P_2 = y\frac{z}{h} = \frac{2P_1 y}{h^2} \qquad \text{.......................... (11)}$$

Substituting in this formula the value of P_1 as above, we obtain

$$P_2 = w\ y\ \tan^2\ (45-1/2\phi)\text{"}$$

The formulae given by Carter are similar to those taken from the Cyclopedia of Civil Engineering, and in both cases the moment is found by assuming the resultant earth pressure to act horizontally at a distance from the toe equal to one-third the vertical height. The formulae of Mr. Meem are based on the assumption that the lateral earth pressure does not increase with the depth and give results quite different from the generally accepted formulae of Rankine.

Theory of Beam

Before proceeding with the design proper, it is necessary that we devote some space to the assumptions made, and formulae employed in the design of a reinforced concrete beam.

The main object in the design of a reinforced concrete beam is to secure the simultaneous occurrence of the specified stresses for steel and concrete. The formulae which we shall adopt are based on the following assumptions:

(1) Plane sections before bending remains plane after bending.
(2) Stresses in steel and concrete are proportional to strain.
(3) Concrete sustains no tensile stress.

The compressive and tensile areas are calculated, and the compressive and tensile stresses are equated. The moment of resistance is found by taking moments about the centre of gravity of compressive stresses, giving the following general equation:

$$M = \frac{cx}{2}\left(\frac{1-x}{3}\right) bd^2 \text{.......................... (1)}$$

$$\text{Or } M = pf\left(\frac{1-x}{3}\right) bd_2 \text{.......................... (2)}$$

Where M = Moment of resistance of beam
f = Working stress in tension of steel
c = Compressive stress in concrete at compression side of beam
b = Width of beam
d = Effective depth of beam, i.e., the depth to centre of gravity of metal
p = Ratio of area of metal to total area bd

dx = Distance from compressive side of beam to neutral axis = (dxX), where X is a ratio.

Other notations are:

$j\,d$ = Arm of resisting couple in beam
E_s = Young's Modulus for Steel
E_c = Young's Modulus for Concrete

$$n = \frac{E_s}{E_c}$$

To find x

$$x = \frac{cn}{f + cn.} \qquad \ldots\ldots(3)$$

To find p

$$p = \frac{cx}{2f}$$

Equations (1) and (2) are generally written,

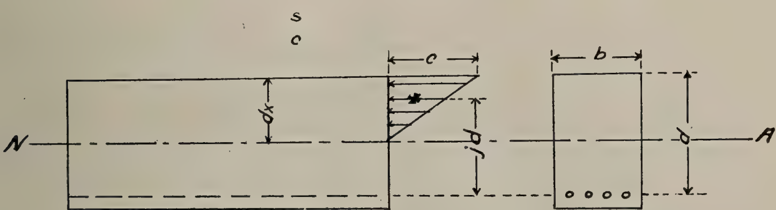


Fig 9.

(5) .... $M = R\,b\,d'$, where R is a constant, and is equal to $cx\ (1—x)$, or $pf\ (1—x$

When $c = 650$ lbs. per square inch
$f = 16{,}000$ lbs. per square inch
$n = 15$,

which are usual accepted values, then

$$M = 108\ b\ d' \qquad \ldots\ldots(6)$$

and,

p = Ratio of metal to area bd
= .0077

also, x = Percentage distance of neutral axis from top of beam.
= .38

Reinforcing Steel

"The steel for reinforcing concrete is not usually subjected to so severe a treatment as ordinary structural steel as the impact effect is likely to be less, but the quality of the steel should be carefully specified. To reduce cost of reinforced concrete structures, there has been a great tendency to use cheap steel. It has been generally recognized in the design of reinforced concrete, that the elastic limit of the steel should be considered as the failing point. It has been shown by beam tests that when the yield point of the steel is reached the beam sags because of the stretching or slipping of the steel, and the top of the beam is likely to fail in compression."

Plain round or square bars depend on adhesion for the union of steel and concrete. This adhesion is partly due to friction, but chiefly to a mechanical bond, formed by the grout of the concrete entering into the irregularities on the surface of the bar.

"Several years ago it was thought that economy could be effected by employing high carbon steel for bridge work. It was found however, that, owing to punching and the irregular stresses produced in plates and structural shapes, high carbon steel was unreliable. For this reason some engineers condemn its use for reinforced concrete. It should be remembered, though, that in this class of work there is no punching of the steel necessary. The stresses in the steel are nearly all tensile, and the ability of the steel to safely withstand them has been proven many times over. Shearing stresses need never be considered either as they are always far within the shearing strength of the steel."[1]

On account of the fact that water percolating through concrete has been proved to reduce the bond between the steel and the con-

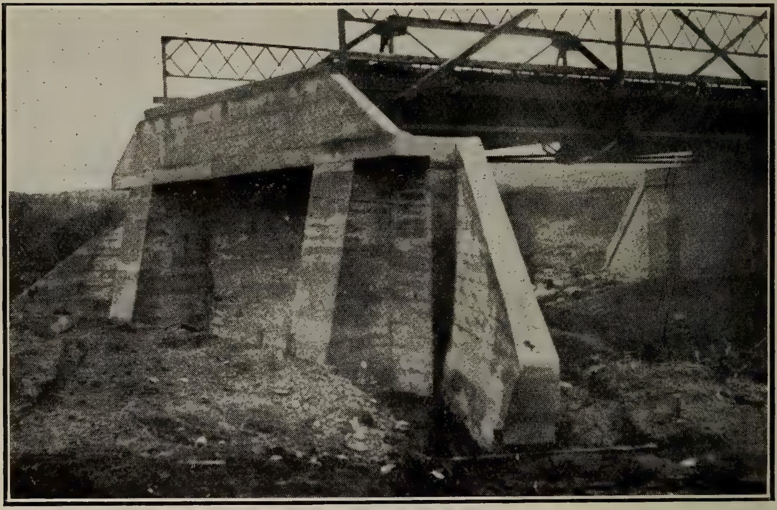


Fig. 10

crete by approximatly one-half, it is always advisable to use, in the footings of concrete abutments, bars having a mechanical bond.

Steel reinforcement embedded in well made concrete, is almost perfectly safeguarded against atmospheric corrosion, but has recently been found subject to deterioration from another source. Injuries which were at first thought to be due to corrosion have later been found to be the result of electrolysis, by stray electric currents, the symptoms of which are deep cracks extending down to the steel on which is formed a red rust, sometimes ¼ in. in depth. To safeguard against this newly discovered cause of disintegration in rein-

(1) T. M. Fyshe, Can. Soc. Civ. Eng., Vol. 20-21, page 179.

forced concrete all steel used as reinforcement in abutments or other structures, which may be used in connection with street railway traffic, or which are in the vicinity of transmission lines, should be in electrical connection by means of binding wires.

Foundations

When rock foundations are unattainable on account of the great depth of soil, piles are driven to increase the bearing capacity of the foundations. If the nature of the soil is accurately known, the number of piles required can usually be determined before the excavations are made. As a guide in determing the necessary increase in bearing capacity of a certain soil, or the allowable stress on foundations of other materials, the following tables of crushing strengths for various materials likely to be used as foundation beds for abutments, are given below.

(1) *Rankine*, Civil Eng. Page 361.

Material	*Allowable pressure per sq. in.*
Granite	12,860
Sandstone	9,840
Sandstone (soft)	3000–3500
Limestone (strong)	8,520
Limestone (weak)	3,050
Clay, Sand and Gravel	17–23

(2) *Baker*, Masonry Constr., Page 10.

Material	*Allowable pressure per sq. in.*
Granite	12,000–21,000
Marble	8,000–20,000
Limestone	7,000–20,000
Sandstone	5,000–15,000
Brick	674–13,085
Clay	28–84
Gravel	112–1,400

The formulae used to determine the average bearing value of a pile under normal conditions is that known as the "Engineering New Formula," i.e.,

$$R=\frac{2\,w\,h}{s+1}$$

where

R = Safe load in pds.
s = Penetration in inches
w = Weight of hammer in pds.
h = Height of fall in feet

It is the custom of the Board of Highway Commissioners for the Province of Saskatchewan to carry the excavation to such a depth that the top of the piles shall be below low-water level. This condition is not required in the case of concrete piles, but the equipment required in driving is more elaborate, and is usually not included in

the plant of contractors doing this class of work, hence wooden piles of 25 feet in length with a minimum diameter at the tip of 6 ins. are always used under normal conditions. These piles are placed principally under the main buttresses, centre of wing walls and toe of footings, and vary from 3 feet to five feet centres according to the requirements of the specific case considered. Spacing is left largely to the judgment of the resident engineer.

DESIGN OF STRUCTURAL STEEL PLANT

E. H. Darling, M.E., '98.

General Conditions Controlling Design of a Plant of 10,000 Tons a Year Capacity

A plant for the fabrication of structural steel for the Canadian market must be equipped for a wide range of work, for, while higher efficiency can usually be attained by specializing on one class, it is not always possible to do so for the following reasons:—

(1) Contracts of a uniform nature cannot always be obtained; and,

(2) Almost any contract has more or less variety of work involved in it.

Certain classes of work, such as building and highway bridge work, are required during the summer months only, while railway work can be done all the year round. By properly combining the two classes there will be less chance of slack seasons for the shop.

But apart from this, as the plant is a new one, whose market is not assured, it should be laid out with the idea of doing general work, and then, as the company finds its place in the business of the country, it may develop those lines which prove to be most profitable.

To secure this desirable flexibility of capacity in a plant having an output of 10,000 tons a year, it will be found advisable to have two main departments: first, a structural shop for all kinds of light truss and beam work, with facilities for handling pieces of five to ten-ton weight. Second, a girder shop where fifty-ton girders can be handled economically. A plant constructed on these lines, with all the necessary subsidiary departments, will be able to turn out any type of railway bridge up to 300 feet in span, and at the same time can be operated efficiently on any ordinary light work.

Location

The location of a structural steel plant is subject to the same general principles that influence other manufacturing enterprises, and, while there may be many secondary conditions that will have more or less weight, the four main ones are: (1) The market; (2) the supply of the right class of labor; (3) access to raw material; and (4) the supply of power.

1. Market

The market for structural steel depends on the class of work sought. Railway work is so widely distributed that good railway connections are of more importance, within reasonable limits, than location. Freight rates do not necessarily enter into the question, as the railways haul all such material and erection equipment, which is for use of their own roads, free of charge. For this reason, as well as others, connection with several railways is desirable. For mill building work, the greatest demand will be in industrial centres, although much of the same class is used in large public buildings, such as armories, churches, auditoriums, rinks, etc. For beam and general building work, such as building contractors require, large commercial and business centres are the best markets. As most of such material has to be transported by team to the building site, good roads are necessary to handle this business. Steel highway bridges are required to replace old spans in the well-settled rural districts, or for new bridges in rapidly growing sections.

In finding the "centre of gravity" of a market, i.e., the point from which it will be possible to serve the largest number of customers freight rates and cost of transyortation should be considered rather than distances. For various causes, due to questions of competition and peculiar conditions existing in Canada, it will often be found that it costs more to make a shipment to a nearby place than to one at a greater distance. From a shipper's point of view, therefore, the latter place is nearer than the former.

The value of a market, however, depends largely upon the amount of competition that will have to be met; so in finding the centre of gravity it will be necessary to assign "weights" to various cities or districts according to how well they are served by existing companies.

2. Labor

The cost of labor in the manufacture of structural steel is such a large percentage of the total cost that the question of obtaining a sufficient supply of the right kind deserves careful consideration. It will be necessary, in the first place, to secure experienced foremen and leaders, and these can only be obtained from other plants. With these as a nucleus it will be possible to train up intelligent laborers to do a great deal of the work, but, owing to the changes that are constantly taking place in a large organization, there will always be a need for men who have had some experience in a structural shop. Such workmen can more readily be obtained at some point near or in easy reach of other structural plants, while at other points it will be necessary to have a well-organized employment department to look after this. As many as two hundred men will be required to operate the plant, who, with their families, may mean that one thousand persons will be supported by it.

Raw Material

Apart from a small amount of machine shop supplies, such as any manufacturing concern uses, "raw material" means only one

thing in the structural steel business, and that is the rolled steel plates, beams, angles, etc., used in fabricating. There were over 600,000 tons of steel imported into Canada last year, and by far the larger part of this quantity was in the form of structural material. Most of this comes from the United States, with Pittsburg as a centre. European manufacturers are at a great disadvantage in competing for this trade, because ocean transportation means more handling and serious limitations to the size and length that can be shipped.

It is of great convenience to a structural steel company to be as near as possible to its source of supply. Not only will it mean a big saving in freight rates at times, but what is often of more importance, it will save delay in getting material, and when mistakes are made in shipments they are more easily remedied.

The further removed a plant is from its source of supply the more necessary it is that a stock of material be carried. This requires a lot of capital, but, as a rule, it will be found very profitable, as well as a great convenience.

Power

Compared with many other lines of manufacture, a structural steel plant does not need as much power in proportion to its output, and in this case not more than two hundred and fifty horse-power will be required. The most convenient form for it, as will be shown below, will be in electrical energy, and it is usually easy to obtain it in manufacturing centres. But it may happen that an otherwise desirable location does not offer this advantage, and then a power plant will have to be installed. This will mean the investment of extra capital and an increase in operating expenses, which must be taken into consideration.

There are a great many secondary conditions that influence a choice of location, such as climate, special inducements from municipalities, personal preference, etc., which will all deserve careful consideration, but it must be remembered that a mistake made at this stage will handicap the industry for all time.

Choice of Site

An ideal site for a structural steel plant is not readily obtainable. A large area is essential, even for a comparatively small plant, while ample provision should be made for growth. Judgment must be used in this particular. Too much land might be a burden to a new company, or, on the other hand, a valuable investment. It should be level and have a water supply and good drainage. It must have at least one railway connection, and more if possible. For immediate neighbors it is convenient to have other iron industries, for these not only supply the smaller items of raw material, but tend to create a larger labor market. The site should be convenient to the homes of the working men, for, apart from the question of wages, no one thing has a greater influence on the problem of building up a permanent and efficient organization than this.

It is not necessary to discuss all the possible variations that may

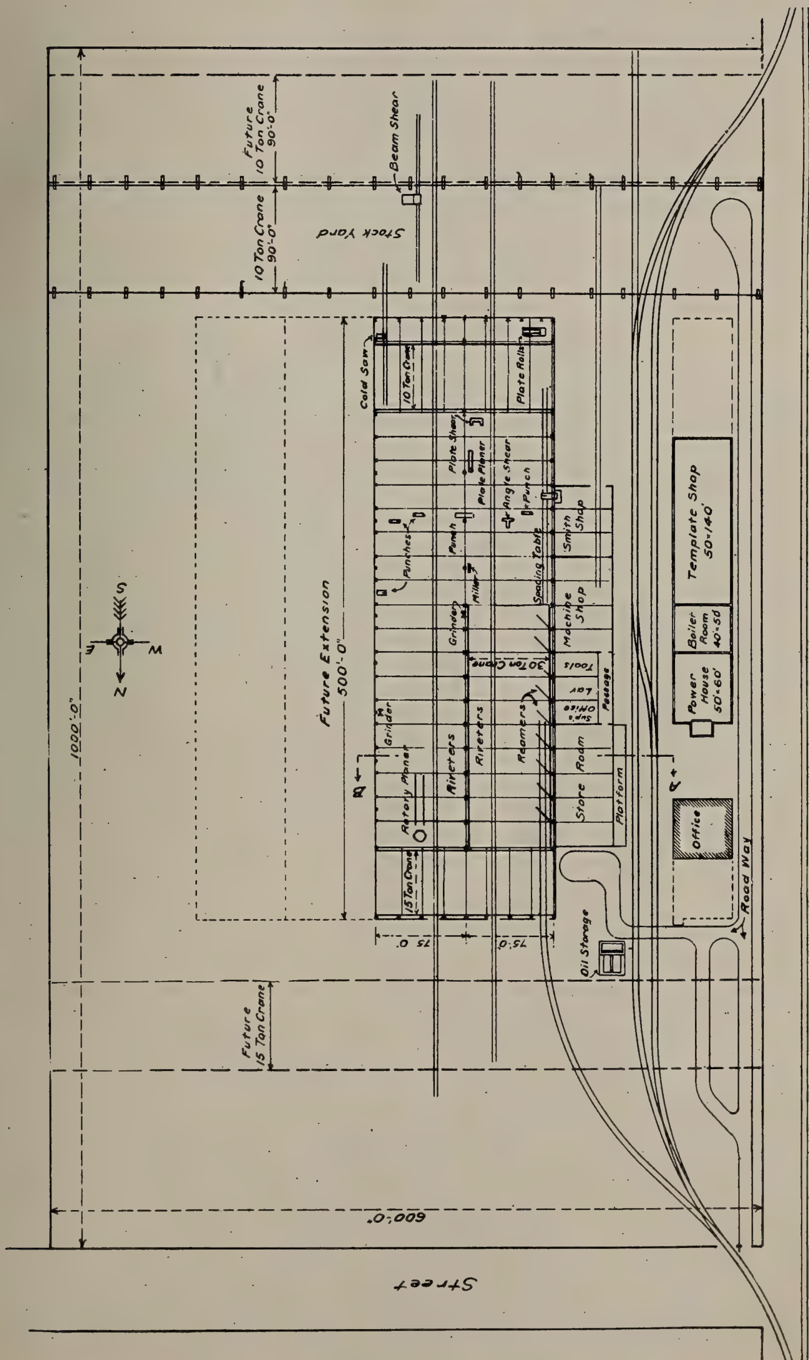

Future
10 Ton Crane
90'-0"
Beam Shear
10 Ton Crane
90'-0"
Stock Yard
Cold Saw
10 Ton Crane
Plate Rolls
Plate Shear
Plate Planer
Angle Shear
& Punch
Punches
Punch
Miller
Spacing Table
Smith Shop
Template Shop
50×140'
Future Extension
500'-0"
Grinder
Machine Shop
Boiler Room
40×50
30 Ton Crane
Tools
Lav
Sup'ts Office
Passage
Power House
50'×60'
Grinder
Riveters
Riveters
Reamers
Rotary Planer
Store Room
Platform
Office
15 Ton Crane
Road Way
1000'-0"
S
E
W
N
75'-0"
75'-0"
Oil Storage
Future
15 Ton Crane
600'-0"
Street

Fig. 1

occur and yet give a satisfactory site, for such things as the shape of the lot, the location and number of railway connections, position of streets, etc., make each site a special study. The necessary, or, at least, very desirable features are:

(1) Sufficient room to arrange the switches and buildings conveniently, leaving ample room for extensions.

(2) A storage yard at one end of the plant where cars may be unloaded and material stored.

(3) A corresponding area at the other end, smaller in extent, to serve as a storage yard for finished work, with facilities for loading it for shipment.

An Ideal Layout

Fig. 1 shows an ideal arrangement for a structural shop on a lot of fourteen or fifteen acres, six hundred feet wide and one thousand feet long, lying north and south. A railway, from which switches can be made, is assumed to run along the west side, and a public street at the north end. The outstanding features of this plan are as follows:

The buildings are placed approximately near the centre of the lot, leaving the ends clear for stock and shipping yerds. The office, power-house and template shop, which will have to be of a permanent type of construction, are placed along one side of the lot, where they will not interfere with future extensions of the plant. The store-rooms and the smaller departments are arranged along the permanent side of the main building for the same reason. The east side is left clear for additions.

The service tracks are brought in between the buildings so that supplies and materials may be readily unloaded just where required. It will be of great convenience to have two connections with the railway as shown. A double track permits the passage of cars, and gives as well more storage room for them. A cross-over between the tracks will be of great service. One track should be run into the shop under the traveling cranes, so shat long and heavy pieces may be loaded directly on the cars. It is very necessary to have easy curves on this, for long girders, loaded on several cars, will be brought out over this track. For this reason, and because heavy locomotives cannot take sharp curves, the degree of curvature should be kept as low as possible. The curves shown have a maximum of 20°, which should be considered the limit. At some future time another track may be put along the west boundary, where cars of the erection department may be stored when not in use.

Regarding the arrangement of the various buildings and departments, it will be noted that the office is placed so as to be the first building approached on entering the plant. Room is left for building on a new front when larger and more elaborate offices are required. The power-house boiler-room and template shop can conveniently be placed in one building, divided by fire-walls, or in a series of buildings. The south end of the template shop may have a temporary end, which will allow it to be extended if necessary, but the power-house and boiler-room should be made of good pro-

portions, as it will not be possible to enlarge these buildings conveniently.

This arrangement places the power-house near one boundary of the site, so that high voltage power lines may be brought into it in

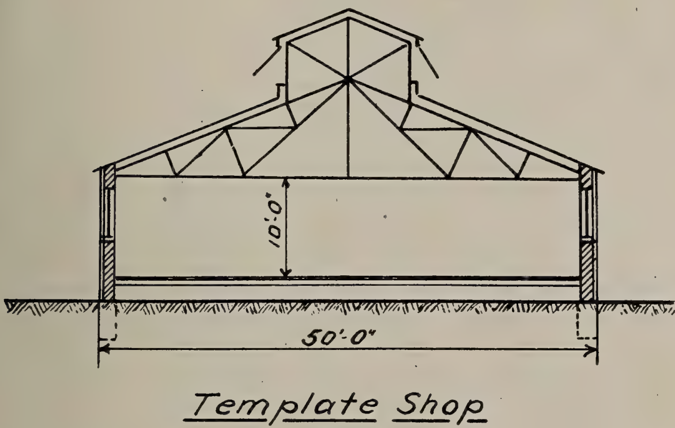


Fig. 2

such a way that all danger of accident from contact is eliminated. At the same time it is at a central point from which it is convenient to distribute the power to all parts of plant. A small tower at the

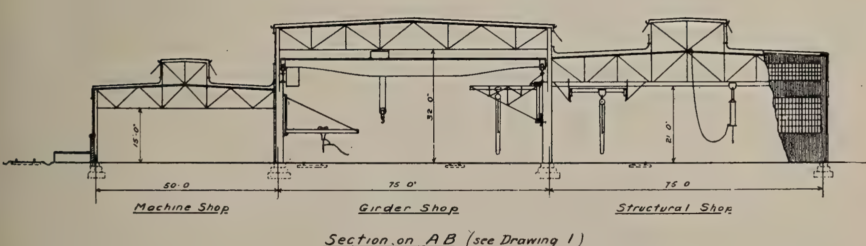


Fig. 3

north end of the power-house forms the transformer room, and the main switchboard may be placed along the wall between this tower and the engine-room.

As the plant will probably be run by electrical power purchased from a power company and not generated at the plant, the boiler equipment will be largely used for heating purposes only. The buildings requiring heat will be the office, power-house, template shop and machine shop, and these are grouped around the boiler-room so as to make the distribution system very simple.

Templates

The product of the template shop is used altogether at the south end of the main shop, where the "markers" do the laying out. It will be desirable, therefore, to have the template shop as convenient to the markers as possible, as shown on the plan. It will also be in easy reach of the drawing office, which is over the business office.

On the other side of the tracks, convenient for receiving and shipping (and also at the permanent side of the plant), are placed the storerooms, machine shop, river and bolt shops, and the blacksmith shop. These departments are relatively small compared with the rest of the plant, and the space allotted should be quite ample for all requirements. Extensions, however, may be added at either end, and the partitions between these departments may be made of temporary construction so as to be easily re-arranged should it be found desirable to make any changes in the future.

The position of the storeroom, with its platform along the tracks and road in from the street, permits supplies to be readily handled. Its proximity to the machine shop, rivet shop and blacksmith shops will save time in transporting materials to and from these department. As far as the main shop is concerned, the largest item drawn from the storeroom will be rivets and bolts and those are used entirely by the assemblers and riveters at the north end of the building. The storeroom is made of good size as by far the larger part of the room will be taken up by bulky equipment for the erection department.

The main shop consists of two seventy-five-foot aisles, one for heavy girders and the other for general structural work. As it will be the structural department that will require to be extended in the future, the girder shop is placed next the storeroom and the way is left open for adding two more aisles to the structural shop. Putting the girder shop in this position makes it possible to bring the railroad track into it.

Buildings

The office building, power house and template shop should be substantially constructed so as to be warm, dry, and fire-proof. The office will be two stories high, the second story being occupied by the engineering staff. The power house and template shop will be a one-storey brick building having a monitor, as shown on the cross section, Fig. 2. The roof is of 2-inch concrete carried on steel purlins and trusses. The windows which take up a large part of the wall space, will have steel sash. The monitor windows will be on hinges so they can be opened, and sections of the other windows will also be made to open. The floor of the power house will be concrete. The template shop floor will be raised eighteen inches or

so above the ground level and be of 4-inch mill construction with an upper flour of inch white pine. This makes a good floor for laying down work upon.

The type of construction to be followed in the main building is shown on the cross section. A large percentage of the exterior walls as well as the monitors will consist of windows which will insure good illumination throughout. The balance of the wall area will be corrugated iron, with the exception of the eight feet below the first row of windows. This will be made a 9-inch brick wall on the north, west and south sides of the building with a concrete window sill to finish it off. This brick wall will make the building much more comfortable both winter and summer.

For the roofs of such buildings as are subject to considerable deflection as well as vibration and shock, it is preferable to use 2-inch matched wood sheeting rather than concrete. As the roof is flat, the covering may be 4-ply felt with tar and gravel.

The frame work will be steel throughout and entirely self-supporting. Steel sash will be used for the windows, as it is only by its use that the large windows can be had.

In dimensions the main building is two hundred feet wide and five hundred feet long. It consists of one fifty-foot and two sevnteyfive-foot aisles with a sixty-foot transverse aisle at each end. An economical length of bay will be twenty feet. The clearance between the bottom chord of the truss and the floor in the seventy-five-foot aisles should be twenty-one feet to allow for air hoists, etc. In the transverse aisles and the girder shop additional head room will have to be provided to allow for traveling cranes. By making the roof at these points as high as the roof on the monitors a good appearance will be obtained. In the machine shop aisle, fifteen feet will be sufficient clearance. Too much height here means a more difficult building to heat, and longer belts for belt-driven machinery.

All trusses whose bottom chords are at the fifteen and twenty-one-foot level should be designed to carry two five-ton trolleys without danger. Use a factor of safety of five for one trolley and of three for two trolleys. For the roof live load at least fifty pounds per square foot should be provided for and, for certain localities where the snow fall is unusually heavy, the live load should be increased. Where there is any possibility that a column will have to carry a jib crane, provision should be made for it in the original design. This refers to the columns in the girder shop where those along the west wall will have to take radical reamers, while five-ton traveling jib cranes for riveting machines have to be supported by the east side. Particular care should be taken with the design of the bracing for the building, and the bottom chord system should be especially heavy to tie the whole structure together rigidly.

To facilitate the transfer of material from one aisle to another the interior columns in the structural shop should be so arranged that the bottom chords of the trusses form one continuous trolley runway from one aisle to another. This is done by spacing the columns forty feet centres and placing them in the middle of a bay,

carrying the roof trusses on longitudinal trusses between these columns. The east wall is filled in with temporary columns to carry the girts and siding. These can be moved further east when another aisle is added. It will be necessary in order to attain economy in shop work, to floor the main building. All things being considered, it will be found that a wood floor will be comfortable for the workmen, reasonably durable, easily repaired, and as cheap as any in first cost. On account of the enormous loads the floor will have to sustain and the rough usage it will receive, it should be made of 3-inch red or white pine. Nailing pieces or stringers of 4 x 4 timber should be bedded in cinders thoroughly rammed and smoothed flush. These pieces should be spaced from three to four feet apart. Every precaution should be taken to keep the sub-floor perfectly dry and if there is any possibility of the wood getting damp, it should be treated with some kind of preservative before laying.

Machinery Equipment

The machinery equipment of the plant is probably the most important question to be considered. Not only does the output of the plant depend on it, but a large proportion of the capital of the company may be invested in equipment and, unless every department is nicely balanced, more or less of it may be unproductive much of the time.

The manufacture of structural steel work requires in its operations the straightening, cutting, shearing, punching, assembling, reaming, riveting, milling and general finishing of a large number of different steel sections.

It would, therefore, be necessry to provide at least machinery for these operations. But the capital invested in a manufacturing plant is subscribed with the expectation of it being able to turn out a certain amount of work which will net a certain percentage of profit. So it will be necessary to have enough machines of each kind to make the capacity of the plant what is desired. For reasons mentioned above, the proportion of each class of work varies widely with different contracts. It therefore becomes a matter of experience and judgment to fix on the amount of equipment to install, as the most careful figuring is at best very approximate. The first item which it is well to fix is the number of riveting machines required. From this the number of punches may be decided upon, and the rest of the equipment proportioned accordingly.

In purchasing machinery certain general rules should be observed. It will be found advantageous in the long run to buy machine having a rated capacity well above the average demand that will be made upon them. Besides the fact that the heavier machine will be more durable, it will in some cases give the plant equipment for a wider range of work at comparatively little extra cost. At the very least it will provide for an emergency which otherwise might prove very expensive.

If the demand for a certain machine product varies widely it will sometimes be found economical (when the cost of operating a

large machine is high) to have two smaller machines instead of a single large one, the first with sufficient capacity for the average requirements and the second capable of taking care of the extraordinary demands. As the plant spreads out, duplicate machines may be required at different locations, it being cheaper to operate two machines than to transport material long distances to have work done upon it.

While complicated machines are to be avoided, it will save capital at the start to buy machines that may be changed over for different classes of work, provided they are not in constant use. For example, the plate rolls should be made a combination of bending and straightening types. The punches should be made so that either cross-cutting or splitting shear blades may be put on to replace the punch and die. The light riveting machine should have one or more extra interchangeable stakes to be used for column or other special work. In this way, at the cost of the extra parts and the time it takes to make the change, work could be done that would otherwise require two separate machines, one of which would probably be idle most of the time.

The matter of punches, shears, reamers, riveting machines and other machines might be taken up at this stage. Their capacities, accessories, and other outstanding features, are in line for careful attention, but the discussion of these items is a little removed from the province of this preliminary investigation of the general lay-out itself, and will not be discussed.

Arrangement of Machinery and Routes for Material

The arrangement of the machinery and the establishing of the routes for the material to pass through the shop is one of the most difficult and perplexing problems in connection with the design of a structural steel plant. In theory the material should enter one end of the shop and pass through it from one department to another emerging at the other end as finished product, without having once been turned around or carried back over any part of its route. In practice, however, there is such a variation in the order in which the work has to be performed—due to details of design and special requirements—that no fixed route can be maintained. At best a material route can be laid out only in a general way, observing the following principles:

Arrange the plant for that class of work which promises to be the most plentiful. If it is necessary that some material be re-handled, let it be the shorter and lighter pieces rather than the long heavy ones.

Sufficient space, sixty-five to seventy feet in the longitudinal direction of the shop, should be left between machines so that, under ordinary circumstances, there will be no crowding or interference. Material over seventy feet in length may be considered very unusual and when, onr are occasions, it becomes necessary to take care of it, more or less difficulty and interference may be permitted. To design the whole plant for it would add very materially to the cost of buildings, while the increase in the distances that the shorter

material would have to be transferred would add to the cost of operation of the plant on regular work.

The material will be sorted out in the stock yard and any with kinks or sharp bends in it will be taken directly to the straightener or plate rolls as the case may be. It will then be put on the trucks, taken into the shop and piled on the markers' skids. From here it will be taken to the various cutting machines, and then on to the punches. As it is punched it will be stacked up until required for assembling, when the various pieces are bolted tightly together, taken to the riveters and riveted up. Reamed work will, of course, be reamed before riveting. The work may now be finished up, cleaned and painted, and as soon as the paint is dry it is ready to ship.

A study of Fig. 1 will show that the machines and department are arranged approximately in the order mentioned above, starting at the south end of the plant. Variations from this rule are due to physical limitations, or are the result of experience.

Handling Machinery and Industrial Tracks

Next to the selecting of the machinery there is no one feature about a structural steel plant that should receive more careful consideration than the handling equipment. The cost of handling is the largest item in the labor account, and the capacity of the plant depends a great deal on the speed with which material is fed to and taken away from the various machines. Even after every unnecessary motion is eliminated, there is a great deal of handling to do to each piece and the weight, length and flexibility of most of them call for care and special appliances.

In the ordinary run of work it is seldom that a piece of material from the steel mills will exceed three tons in weight. The stock yard crane, however, should have at least ten tons capacity as it is usually desirable to lift several pieces at one draft. Only one crane, having a ninety-foot span, traveling the full width of the lot, will be needed at first. At some future time another crane and runway may be added, which will not only increase the handling capacity, but will double the area of the stock yard.

This yard crane will unload material from the cars and sort it. As it is required in the shop, it will be put on small trucks which run on narrow-gauge tracks from one end of the shop to the other. Inside the building the hoists on the bottom chords of the trusses afford a means by which the material may be taken off the trucks and transferred to any point across the shop. At each end of the building, however, on account of the great deal of handling that takes place, at these points, it is advisable to have traveling cranes of about sixty-foot span—a 10-ton crane at the stock yard end and a 15-ton crane at the shipping end. These cranes will also be found of great service in transferring material from one aisle to another.

At the punches, longitudinal trolley beams with trolleys and chain hoists are necessary to hold the work as it is fed through the machine. These trolley beams must be suspended below the trusses

and have openings for the trolleys on the trusses to pass through. Special travelers and jib cranes can be arranged to suit the need of any particular machine.

In that part of the girder shop where the girders are assembled and handled, it will be necessary to have two traveling cranes of thirty-ton capacity. Traveling jib cranes for carrying riveting machines can be arranged to run along the east side underneath the over-head cranes. In the structural shop the riveters will have 3-ton traveling cranes with fifteen foot span carried on runways suspended from the roof trusses.

Three- and five-ton air hoists will be required wherever much lifting is to be done, provided the head room is sufficient for the hoist. For holding work at machines, however, a chain block is better, as air hoists are not steady enough. Wherever possible, material will be laid on horses or skids, so as to save raising and lowering more than necessary. If much of it has to be done at any point, rapid-acting blocks should be used.

In course of time it will be found convenient to have a thirty-ton traveling crane with seventy-five-foot span in the yard at the north end of the plant. Under it finished material may be stored and loaded for shipment as required. It can be used for assembling large trusses when it is necessary to put them together at the works before shipping.

All the thirty-ton cranes should have 5-ton auxiliary hoists, or should be provided with change gears, as some cranes are now made. This will save a great deal of time when the crane is used for handling light pieces, the slow motion or main hoist being used only for heavy loads.

The handling equipment under certain conditions should include a 10-ton locomotive crane. Such a machine will be found of great service during construction for unloading and placing building materials, machinery, etc. It will also be a great convenience, if not a necessity, in moving cars, unless unusually good shunting service is available from the railway company. It may be used to good advantage by the erection department for certain work.

All parts of the handling equipment should have a wide margin of strength. Chains, hooks, cables, chain blocks, etc., that are frequently overloaded, soon give trouble and become dangerous. The most serious accidents of a structural steel shop are the result of falling material.

Power and Lighting Systems

Electric power is usually delivered as two-or three-phase alternating current at a high voltage, to be transformed to suit the requirements of the purchaser. For distribution about the plant a voltage of 220 or 500 volts is usually used. The higher voltage requires less copper in the feeders, but for a structural shop the lower voltage, i.e., 220 volts, is preferable. The presence of so much metal, the rough treatment which wires and conduits are liable to receive, makes it unwise to use a voltage that might be dangerous to workmen.

The power equipment must include a motor-generator set, as

direct current will be required for variable speed motors, such as cranes, reamers, etc. The motor side of this set should be of the synchronous type with sufficient capacity to correct the power factor of the plant. On account of the varying loads on the motors, the power factor is sure to be very low. The capacity of the generator should be well able to take care of the needs of the plant, including the lighting system and the extra traveling cranes which might be added in a year or two. A set with a capacity of 100 kilowatts direct current and a synchronous motor of 125 k.v.a. should give satisfaction.

The high voltage current will be brought down the tower at the end of the power house to the transformers, and from thence the low voltage current will be taken in conduits to the bus-bars of the switchboard. A separate switchboard will be needed for the direct current system. From the switchboards feeders in conduit will run to the machines in the power house and template shops. For the main shop the feeders will pass up the tower and overhead to cross-arms on the trusses of the building. A separate system, each on its own switch, should be provided for the different departments, so that any one can be cut out without interrupting the others. There should be three sets of A.C. feeders, one for each aisle of the shop, with room on the cross-arms for the additional aisles to be added later. There should be two pairs of D.C. feeders, one for the north cranes and one for the south cranes. If separate switches are provided at convenient points for cutting out each crane, it will hardly be necessary to have separate feeders for the other D.C. machines in the shop. There will only be one or two of these machines other than the reamers.

All wires above the bottom chord of the trusses will be carried on cross-arms bolted to the steel work, but wires below this level must be put in metal conduits. The starting switches for each machine should be as near the machine as possible. For the portable reamers a series of outlets must be provided on the columns about every forty feet down the shop so that the reamers can be connected up by means of a plug and a flexible chord wherever needed. Each outlet and, in fact, every branch circuit, must have a separate cut-out. In this and in all other particulars the rules of the fire underwriters must be followed, and every precaution taken to prevent short circuits and injury to the workmen.

For general illumination modern D.C. flaming arc 110-volt lights give as suitable and as economical a light as any. One light in every other bay arranged alternately on the right and left-hand side of the centre of each aisle will be sufficient for general illumination, while they may be spaced closer over the laying-out skids and the assemblers. As the power circuit is 220 volts, it will be necessary to connect two lights in series. Each pair must have a cut-out and every four lights should be controlled by a two pole switch.

Sixteen-candle-power incandescent lights must be provided for each machine. These must be on good lamp chord and protected by wire cages having wooden handles. The power for these lights

Compressed Air Systems

The transmission of power by means of compressed air is a very expensive method, but it is so convenient to handle, and can be adapted to so many uses, that it would be impossible to get along without it. A pressure of 90 to 100 lbs. per square inch is usually used for operating pneumatic riveters, hammers, reamers and hoists. The plant can easily be supplied by a 700-foot-per-minute, two-stage compressor. When the demand gets beyond this, it will be advisable to add a 1,400-foot machine to the equipment and the piping, etc., should be installed at the outset with this object in view. By having two machines of different capacity, the varying demand for air can be supplied a great deal more economically than by one large compressor.

The compressor will be belt-driven by a 125-h.p. induction motor. It should have an automatic throttling device which will cut off the supply of free air completely when the pressure in the system reaches its maximum. Such a governor can be adjusted to regulate the pressure within three pounds. This small variation need not be considered, as the method is much more economical in power than if a regulator were used which would permit just enough air in the intake to maintain the pressure constant. It causes great fluxations in the power used, however, as the compressor runs light when the intake is cut off.

In order to keep the pressure in the distribution system as constant as possible, and to relieve it of shocks, it is necessary to have a storage tank near the compressor. This tank will also act as a cooler, and in it will collect a great deal of the moisture that would otherwise pass into the distribution pipes. A large second-hand fire-tube boiler can be converted into a splendid storage tank. It should be set in a vertical position so as to allow a natural circulation of air through the tubes. The inlet should be near the top and the outlet about eighteen inches from the bottom. A convenient place for this tank is in a corner of the boiler-room. From it the air main can be taken underground to the centre of the main shop, and from thence by three vertical branches to the roof trusses, one branch each for the air hoists in the girder shop and structural aisles and one branch with drop pipes down every other column of the centre row, having outlets for the riveting machines, reamers, etc.

All horizontal pipes should be given a slight slope downward in the direction of the flow of air so that any moisture that is carried past the storage tank will not obstruct the flow. At the tank and at all low points in the system blow-off valves must be provided to the drains, and these should be opened at regular intervals. Care in this particular and abundantly large pipes will do away with all trouble from frost in winter. It will not pay to provide special means to re-heat the air before using, and it is not convenient to arrange a satisfactory indirect method.

A low pressure system—about twenty pounds per square inch—will be required for the oil forges. The blower, which will be driven by a small motor, can be supported between the trusses. The dis-

may be obtained by tapping the circuit that supplies the machine.

For the template shop the best illumination can be obtained by means of 100-watt tungsten lights suspended from the roof, three in each twenty-foot bay. Along the walls, over tables, or near machines, 16-candle-power carbon lights on drop chords will be used to give special illumination where needed.

tribution system, which will be made of galvanized iron pipes, will be carried over head and down columns near the rivet forges. Ultimately a separate blower will be required for the rivet-making plant and the blacksmith shop, but for the present the one machine will do.

Water Supply System

Apart from the amount of water required for drinking, sanitary purposes and fire protection, it will only be used for the water-cooler of the compressor, and in the boiler of the heating plant. A 6-inch pipe will supply enough for several fire streams if the pressure is good. The source of supply will probably be a public main on the street to the north of the property. The best place to bring in the private main is along the west boundary. Here it will be always accessible and not likely to be covered up with materials, etc., and furthermore, in case of a break it cannot do much damage to tracks or foundations. Where the first branch in the main occurs a manhole should be built and a valve placed on both lines leading away from it. In fact, it will be found of great convenience to have plenty of valves in the system so that any one section may be cut out with the least possible interference with the rest of the system. It is most important that the supply for the water-cooler on the air compressor be as independent as possible, for the lack of a little water here will practically stop the operation of the plant.

Hydrants should be placed at convenient points, but not too near the buildings. By having them near the tracks they may be used for supplying the locomotive crane. An automatic sprinkler system should be installed in the template shop.

The ends of all branches should be arranged with plugs or caps so as to permit of being extended as the plant grows, and tees should be put in at points wherever there is the slightest possibility that a branch might be needed in the future.

Sewers and Drains

The drainage system and its arrangement will depend entirely upon local conditions and the amount of fall obtainable. With a minimum grade of 1-8 inch in one foot for a twelve-inch glazed tile sewer it will require three such to properly drain the plant as first constructed. Assuming that they empty into a trunk sewer on the street and that they are to be four feet deep at the manhole in the stock yard, the trunk sewer will have to be at least thirteen feet deep where the drains enter ino it. If the depth be a little more than this, something might be saved in cost by running one twenty-four-inch sewer about three hundred feet into the property and connecting the twelve-inch sewers to it. The question of sewers, however, depends

so entirely on local conditions that nothing in the way of a definite design can be worked out at this stage. In general, however, it may be said that in addition to providing for carrying off the rain water from the buildings and the sewage, the surface water that may collect on the site must be taken care of. Special care should be taken to keep the sub-grade of the tracks well drained. All pits for machinery and other low spots should be connected with the sewers as well as all drain-offs and drips from water taps, steam pipes, etc. Sewers other than tile drains should not run near foundations if it can be avoided. In case such arrangement is found necessary, then the foundations must be carried down below the level of the sewer. Manholes with catch basins should be built at all junctions of the large sewers.

Fuel Oil System

Where light fuel oil of a uniform grade and at reasonable price is readily obtainable, its use in riveting heating forges and other furnaces is well worth considering. The rapidity with which a furnace can be heated, the ease in obtaining a uniform temperature, and the absence of the dirt incidental to the use of coal and coke, are all points in its favor. Only satisfactory results can be obtained, however, from a correctly designed system, and while for a small plant the first installation will be expensive, it may be easily extended in the future at very little cost.

The great secret of success with fuel oil is clean oil of a uniform grade, and large distribution pipes. For storage purposes two 12,000-gallon iron tanks will be required. These are to be buried in blue clay near the tracks at least thirty feet from other buildings, so that a tank car may be unloaded into them by gravity. The tanks should have one end exposed in a pit or concrete cellar roofed in to protect it from the weather. This pit should be large enough to contain a small electric pump which will be required to maintain a sufficient pressure in the distribution system. The first tank serves as a receiving and settling tank. The second tank is connected with the first by a pipe so as to draw off the oil a foot or two from the bottom of the first. It will be necessary to drain the sediment out of the settling tank at regular intervals.

The distribution system should not be made of less than 1¼-inch pipe and should form a closed circuit or duplicate system, having a return pipe or overflow back to the second tank. By this means the oil is kept circulating at all times, and congestion from any cause is prevented. If trouble should occur at any point, that section may be cut out by means of valves and the rest of the system need not be interrupted.

For keeping the oil from congealing in winter, steam coils should be put in the storage tanks and the distribution pipes should be laid in iron casing through which steam may be blown.

Heating System

The question of heating structural steel plants deserves special consideration in each particular case. It is a question that is involved

in the choice of a location. To heat brick buildings of ordinary type is not necessarily a very difficult problem. The office can be heated by means of steam coils in the usual way. For the template shop, compressor room and machine shop a hot air system with fan will give satisfactory results if properly designed. This system is cheaper to install than steam coils and interferes less with the arrangement of the benches, machines, etc.

The heating of the main building is a more difficult problem. The volume of air to be heated is so great, uncontrolled by partitions, the conductivity of the corrugated iron and glass which forms the walls is so high, and the large doors have to be opened so frequently, that the cost of a plant that will give satisfactory results is almost prohibitory, to say nothing of the cost of operating it. Then, again, the capital invested in a heating plant lies idle a large part of the year. In fact, in Southern Ontario severe weather seldom lasts more than a few days at a time at intervals during the winter months. Under such conditions a heating plant is not necessary as "salamanders" or open fires burning coke or charcoal can be placed around at convenient points. The cost of such fires, even with the time lost by the workmen in keeping warm added to it, will not equal the interest on a heating plant and the cost of operation.

If care is taken to make a corrugated iron building airtight, it will be found to be much warmer than such a building is usually expected to be. Large glass areas, such as are becoming so common in manufacturing buildings, if in a south wall, will produce the same warming effect which takes place in a greenhouse. This will add very materially to the warmth of a building on bright days, but it must be counteracted in summer time by good ventilation and circulation of air. Ribbed glass must also be used to diffuse the light.

Erection Equipment

The equipment required for erecting steel work is merely to be mentioned here to call attention to it as being an item not to be overlooked. Such equipment depreciates so rapidly and the requirements vary so much with every contract, that a large part of the cost of it should be charged up to the work on which it is first used. This should be taken into consideration in making up the estimate for a piece of work. Special equipment, such as travelers, derrick cars, etc., can safely be left for consideration when the time comes to take contracts that require their use.

S. Hett, '06, is locating engineer for the Hudson Bay Railway at Le Pas, Man.

H. A. Dixon, '00, is district engineer for Mackenzie, Mann & Co., on the Canadian Northern Pacific Ry., with headquarters at Resplendent, B. C.

E. H. Darling, '98, is engaged in consulting practice as a member of the firm of McPhie, Kelly & Darling, architects and engineers, Hamilton.

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EDITORIAL

EMPLOYMENT

The Engineering Society employment bureau has been of service to a smaller number of men than usual this spring, and the reason is not hard to define. The general depression which pervades throughout the country, owing to the tight money markets, and their direct result upon most lines of development work has resulted in fewer calls for the services of undergraduates, without more enquiries from them in turn.

Inability to place a number of our students this year shows the necessity of extending our powers, before another year, to embrace larger fields. In such a prosperous year as that of 1912, men were lacking; applications for them went a-begging. This summer shows a complete reverse. It is a condition like the

present which shows the necessity of fundamental strength and established reputation.

The first requisite towards this end is on the part of the students themselves. Being "School" men does not in itself turn out satisfactory services or build up for the School, or for themselves, a reputation. Their work in field, shop and office should be such as will stand the test of the chief engineer's scrutiny. A good engineer's work is always characteristic of accuracy and precision.

Their co-operation with engineering firms should be carefully cultivated and maintained. Filling positions must not be done in haphazard style. Careful selection is necessary and it must be remembered, at all times, that it is the need of the firms which must be filled; the applicant's desire for the job is secondary. Graduates should not think lightly of the students' reliance upon them for all the assistance they are in a position to give, to facilitate ready employment after exams. It may be that in their student days they "rustled" their summers' employment with little or no assistance, and are of the opinion that a School man can always do the same, forgetting, perhaps, the hundreds of School men yearly seeking employment, as against only dozens in their day. Again, the University does not realize the importance to it of fostering this healthy relationship between its product and the units of an industry throughout the country. The University is more or less disposed to regard all else as foreign, that has no position in the curriculum. These are a few things that have such a direct bearing on the ideal working of our employment bureau, that they should be well considered.

THE D. SC. DEGREE

The Engineering Society shares a part of the honor which the University conferred upon one of our most prominent graduates, T. Kennard Thomson, D.Sc. Among School men there are none to whom the honor is more fitting. It is the first official recognition that the University of Toronto has shown a man in the engineering profession, and we are glad that the first to have received the new degree of Doctor of Science is T. Kennard Thomson, S.P.S., '86.

A. J. Huff, '11, is in Edmonton, Alta., with the Huff Gravel Co., Limited.

H. H. Depew, '04, is a member of the firm of Depew & Hillas, dealers in electrical supplies, Edmonton.

J. E. Davison, '00, is in Victoria, B.C., where he is engaged in the real estate business.

Gordon Pace, '04, is engineer and general superintendent for the Simcoe Railway and Power Co. at Midland, Ont.

DIRECTORY OF THE ALUMNI

This department began in November, 1912, and the entire list of graduates will be reviewed before the end of the year.

A number of corrections have been received bearing upon the part of the directory which has already been published, and our list of addresses is thus becoming more authoritative. If those whose names will appear during the next several months will assure themselves that our record of their location and employment is correct before publication, it will be improved still more, as there are some addresses upon our files that are long standing and hardly to be depended upon.

(H)

Hackner, J. W., '08, whose home is in Sandford, Ont., is assistant engineer for the Department of Public Works, Ontario.

Hagarty, R. E. W., '07, is manager of the Regina office of the Trussed Concrete Steel Co., of Canada, Limited.

Haight, H. V., '96, is chief engineer for the Canadian Ingersoll Rand Co., Sherbrooke, Que.

Hall, H. G., '11, whose home is at Woodstock, Ont., has left no other address with us.

Hall, K., '07, has 39 Sherman Ave., Hamilton, as his residence. No professional data is on file.

Hamer, A. T. E., '01, is on the engineering staff of the Canadian Northern Ontario Railway, and is resident at cochrane, Ont.

Hamilton, J. F., '03, is a member of the firm of Hamilton & Young, Dominion Land Surveyors and Civil Engineers, Lethbridge, Alta.

Hamilton, C. B., '06, is owner and general manager of the Hamilton Gear and Machine Co., Toronto, Ont.

Hamilton, C. T., '07, is in Vancouver B. C., residing at 1414 Haro St., and is a member of the city engineer's staff.

Hamilton, G. M., '11, is on the engineering staff of the Welland Canal, at Welland, Ont.

Hanley, S. C., '93, used to be with the Midland (Ont.) Engine Works Co. We do not know his present location or employment.

Hanes, G. S., '03, is city engineer of North Vancouver, B. C.

Hanning, G. F., '89, whose home is in Toronto, is divisional engineer for the Canadian Northern Railway at St. Eustache, Que.

Hara, L. D., '04, is resident in St. Catharines, Ont., as resident engineer on the Welland Canal construction.

Hare, R. A., '07, is in charge of the test department of the Canadian Crocker Wheeler Co. at St. Catharines, Ont.

Harcourt, F. Y., '03, is assistant engineer, Department of Public Works for Ontario, at Port Arthur, Ont.

Harcourt, H. E., '11, is resident engineer, main drainage departmant, City of Toronto.

Hare, W. A., '99, is president and managing director of the Hare Engineering Co., Limited, Toronto.

Harkness, A. H., '95, is senior member of the firm of Harkness & Oxley, Consulting Structural Engineers, Toronto, Ont.

Harkness, A. L., '06, is in the engineering offices of the St. Lawrence Bridge Co., Montreal, Que.

Harper, C. J. ,'09, has been surveying in the Peace River territory for the past two years.

Harris, C. J., '04, resides in Brantford Ont., in the employ of the Brantford Screw Co.

Harris, J. H., '10, is superintendent for W. Harris & Co., manufacturers of glue, fertilizers, etc., Toronto, Ont.

Harrison, R. L. ,'06, is engineer in charge of the Toronto Eastern Railway, and resides in Oshawa, Ont.

Harrison, F. W., '05, is assistant to the chief engineer, Brooklyn (N.Y.) Edison Company.

Harrison, E., '06, is senior member of the firm of Harrison & Ponton, engineers and surveyors, Calgary, Alta.

Harston, R. G. L., '09, is superintendent for W. S. Tomlinson & Co., Contractors, Toronto, Ont.

Hartney, J. C., '06, resides in Vancouver, B. C. We believe he is in the

employ of the Canadian Westinghouse Co., in their Pacific coast office.

Harvey, C., '01, resides in Kelowna, B. C. He is a consulting civil engineer and land surveyor.

Harvey, D. W., '09, is resident engineer, department of railways, bridges, and docks, city of Toronto.

Harvie, N. J., '10, whose home is in Orillia, Ont., has no record of professional employment with us.

Hastings, M. B., '10, is sales engineer for A. H. Winter Joyner, Limited, electrical supplies, Toronto.

Haultain, H. E. T., '89, is professor of mining engineering, University of Toronto.

Haveland, F. L., '08, is with the Hamilton Bridge Works Co., Hamilton Ont., as draftsman.

Hay, C. O., '09, deceased, September 5, 1911.

Hayes, L. J., '03, is manager of the Niagara Falls (N.Y.) office of the Development and Funding Company.

Heebner, M. B., '11, is at Coquitlam, B. C., as assistant engineer for the Foundation Company, Limited, on the construction of the C. P. R. Pitt River bridge, main line.

Helliwell, J. G., '10, is on the design of structural steel work with the Canadian Bridge Company at Walkerville, Ont.

Helson, F. J., '07, is division engineer for the Canadian Northern Ontario Railway, at Hoben, Ont.

Hemphill, W., '00, is superintendent of lines for the Cataract Power and Conduit Co., Buffalo, N. Y.

Hemphill, J., '09, is construction engineer for the mines department Algoma Steel Corporation, with headquarters at Magpie Mine, Ont.

Henderson, E. E., '85, although we do not hear from him, we have no knowledge of any change from his old address, Henderson, Maine.

Henderson, F. D., '03, resides in Ottawa, Ont. He is on the staff of the topographical surveys branch, Department of the Interior.

Henderson, S. E. M., '00, who has been in charge of the switchboard department of the Canadian General Electric Co. at Peterborough, Ont., is now with the company in Toronto.

Henderson, C. D., '08, is with the Canadian Bridge Company at Walkerville, Ont.

Hendry, M. C., '05, whose home is in Toronto, is with the waterpower branch, Department of the Interior, Ottawa.

Henry, J. A., '00, resides in Schenectady, N. Y. He is with the General Electric Company as designing engineer.

Henwood, C., '02, was with the National Tube Co. at McKeesport, Pa., when last heard from. We do not know his present location.

Herald, W. J., '94, who was with the Canada Foundry Company for some time has no address with us since then.

Hermon, E. B., '86, is in Vancouver, B. C., where he is in the employ of the Vancouver Power Co., as assistant chief engineer.

Heron, J. B., '04, is with the Canadian Northern Railway Co., at North Bay, Ont., as district engineer.

Hertzberg, C. S. L., '05, is a member of the firm of James, London, & Hertzberg, structural engineers, Toronto, Ont.

Hertzberg, H. F. H., is chief engineer for the Trussed Concrete Steel Co. of Canada, Limited, Walkerville, Ont.